

# *Sensitivity Calculations*

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Sensitivities are used as measures of robustness for engineering systems. In many applications, one is interested about the system performance under small variations of a set of design parameters. In inverse device design, sensitivities guides the search within the space spanned by a set of design parameters.

## *Problem Formulation*

Assuming  $\mathbf{G}$  is a vector of design merits  $(G_1[\mathbf{x}], G_2[\mathbf{x}], \dots, G_n[\mathbf{x}])$ , where each component is a scaler function of  $m$  design parameters  $(x_1, x_2, \dots, x_m)$ . The goal is to find the sensitivity of the design merit  $G_i$  with respect to the design parameter  $x_j$ :

$$S_{ij} = \frac{dG_i}{dx_j} \quad (1)$$

The Jacobian  $S$  will be an  $n \times m$  matrix, which maps  $m$  input parameters to  $n$  output merits.

## *Numerical Differentiation*

*Finite Difference Method*

*Complex Step Method*

*Automatic Differentiation*

*Automatic Forward-Mode Differentiation*

*Automatic Reverse-Mode Differentiation*